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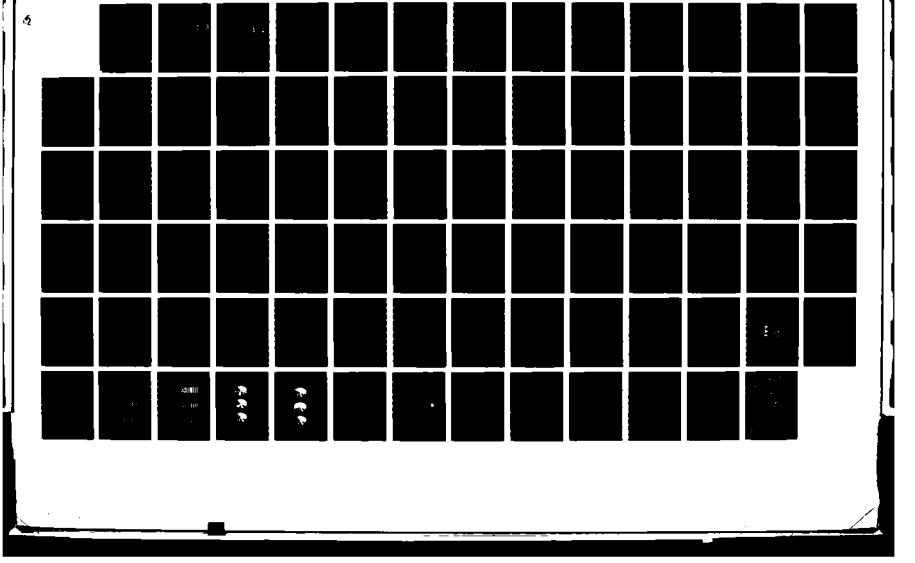

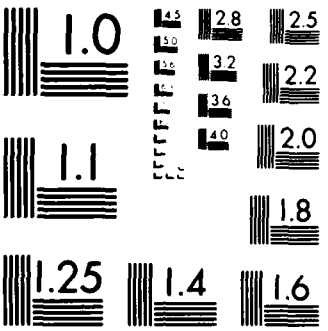

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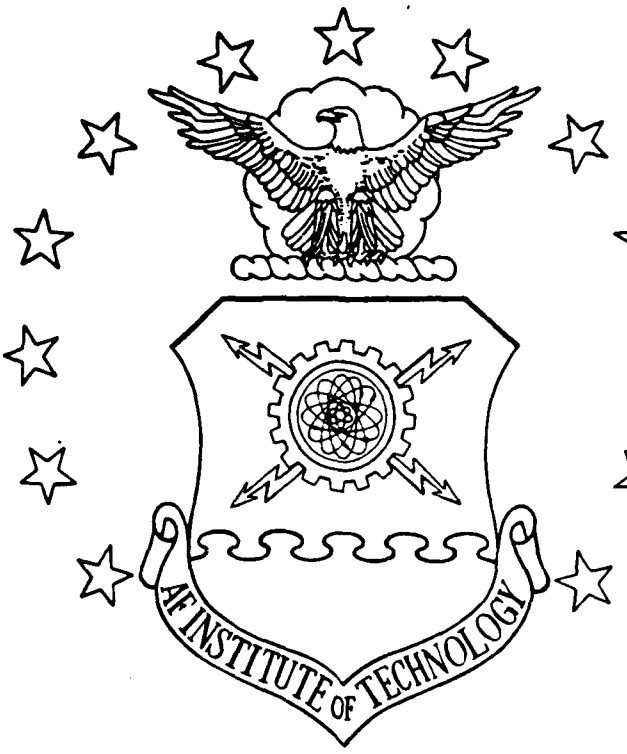

MANAGEMENT INFORMATION SYSTEMS DESIGN IMPLICATIONS: THE EFFECT OF COGNITIVE STYLE AND INFORMATION PRESENTATION ON PROBLEM SOLVING

THESIS

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THESIS

Presented to the Faculty of the School Of Systems and Logistics

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First Lieutenant, USAF

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To all of you: Thanks.

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Abstract

The objective of this research was to identify a relationship between psychological type and mode of presentation of information. The type theory developed ty Carl Jung and operationalized by the Myers-Briggs Type Indicator (MBTI) was used to identify psychological type. The information presentation data were collected through an Information Presentation Mode Survey.

The population studied was graduate students at the Air Force Institute of Technology. The results of the MBTI were combined to show cognitive style. The Information Presentation Mode Survey gathered data regarding accuracy, efficiency and preference rankings for seven different modes of presentation of data.

The statistical analyses showed no relationship between personality type and presentation mode, however sample size made analysis difficult. Trends evident in the data suggested that personality type and presentation modes were related.

MANAGEMENT INFORMATION SYSTEMS DESIGN IMPLICATIONS:

THE EFFECT OF COGNITIVE STYLE AND

INFORMATION PRESENTATION ON PROBLEM SOLVING

I. Introduction

Background

The Department of Defense spends increasing amounts each year on sophisticated hardware for information systems. Managers at all levels depend on these systems to aid their decision-making. This sophisticated hardware allows users to more easily interact with the information systems. However, more sophisticated hardware only partially solves the problem of how to effectively use these systems to make decisions.

To be effective, information systems must handle three distinct stages of processing. The first stage is raw data. The second stage converts the raw data into information by grouping, consolidating, and otherwise combining the raw data into logical parts. The third stage is presenting the information to the manager in a way that optimizes the information's use to the manager. This third stage acts like a bridge between the computer and the manager, it involves both the capabilities of the computer in the ways of presenting information, and also the attributes of the manager in the way the information is used and understood. This research deals with this latter portion of the third stage, the need to know more about humans as information processors.

Mason and Mitroff proposed a format for future systematic research in the area of Management Information Systems (MIS) that included the observation that

> . . . an information system consists of at least one person of a certain psychological type who faces a problem within some organizational context for which he needs evidence to arrive at a solution and that the evidence is made available to him through some mode of presentation [Mason and Mitroff, 1973:475].

This proposed format theorizes a direction for research in information systems that includes the idea of psychological type influencing the effectiveness of information systems.

Psychological type refers to the specific individual differences. While psychological types may be categorized in several ways, this research uses cognitive style as a measure of type. This stance is supported by prior research in the area of information systems and individual differences, as found in the literature review in the second chapter.

Mode of presentation is the way that data is presented to the user. Due to the high cost of manually creating graphs and charts in the past, the most convenient, easily understood, and often the only available means of presenting data was tabularly (rows or columns of numbers). With the computer came options. Computers can more easily transform tabular data into various forms, such as bar charts, line graphs and pie charts. Along with the options came questions. What mode of presentation is the most effective? Is the most effective mode the same for all users? Are different modes best suited for certain different applications? Is there an effective way to predict which mode

of presentation is best suited for an individual, if there are differences between users?

Research in the last ten to fifteen years has attempted to answer these and similar questions concerning the presentation of information. This research focuses on a specific aspect of presentation of information, namely how individual differences (cognitive style) of users interact with the different modes of presentation (graphical, tabular, and combined modes).

Research Problem

There are many variables which the designers of information systems must consider. Some of these variables determine which mode of presentation should be used. Two of these variables are the type of problem to be solved and the psychological type of the users.

Benbasat and Taylor realized the significance of the type of problem when they identified the possible benefits of each type of presentation mode prior to their conducting their experiment. They summarized the following, given their type of problem:

> Tabular reports will assist in determining the optimum solution by providing the exact figures to calculate [the solution]. Graphical reports will provide a quick understanding of the area where a good solution to the problem lies as they display [information] by relationship over the entire range of possible [information] [Benbasat & Taylor, 1986:67].

Perhaps not all managers may use information the way Benbasat and Taylor have summarized above.

As postulated by Mason and Mitroff, the psychological type of individuals may also influence the usefulness of data. If this were

true, managers should receive information in the way it is most useful to them as unique individuals. Based on this, information should be tailored to specific managers just as it is tailored for specific uses.

There are methods to transform information into graphics or charts with computers and there are ways of measuring individual differences (psychological type). If psychological type has an influence on the usefulness of the different presentations of information, then psychological type should be used to determine the way information is presented.

Central Research Question

This research attempts to find out if there exists a relationship between psychological type and the usefulness or effectiveness of different methods of presentation of information in problem solving.

The research question this study intends to answer is: Is the psychological type of an individual related to the accuracy, preference, or efficiency of problem solving when using different modes of presentation of information?

The null hypothesis for the main research question is:

H_0: There is no relationship between the psychological type of an individual and the individual's accuracy, preference, or efficiency when using different modes of presentation of information when problem solving.

The associated alternative hypothesis is:

H_a: The psychological type of an individual is related to their accuracy, preference, or efficiency when using different modes of presentation of information for problem solving.

Subsidiary Research Questions

In order to answer the central research question, the following subsidiary research questions and hypotheses will be tested:

1. Do the subjects have different psychological types than the general public?

H_0: The subjects have the same distribution of psychological types as the general public.

H_a: The distributions of types are different.

2. Are subjects more accurate using some modes of presentation when compared to other modes?

H_0: Subjects have equal accuracy when solving problems using different modes of presentation.

H_a: Mode of presentation and accuracy are related.

3. Is the psychological type of a subject related to the accuracy of problem solving when using different modes of presentation?

H_0: The psychological type of a subject has no relationship with the accuracy of problem solving when using different modes of presentation of information.

H_a: Psychological type and accuracy are related.

4. Do subjects prefer some modes of presentation over other modes?

H_0: Subjects have equal preference for all modes of presentation of information.

H_a: Subjects prefer some modes over others.

5. Is the psychological type of a subject related to the preferred mode of presentation of information?

H_0: The psychological type of a subject has no relation to the preferred mode of presentation.

H_a: Preference and psychological type are related.

6. Are the preference rankings of presentation modes related to their accuracy in problem solving?

H_0: The preference for mode of presentation of information is not related to accuracy.

H_a: Accuracy and preference are related.

7. Are subjects more efficient using some modes of presentation when compared to other modes?

H_0: Subjects have equal efficiency when solving problems using different modes of presentation.

H_a: Mode of presentation and efficiency are related.

8. Is the psychological type of a subject related to the efficiency of problem solving when using different modes of presentation of information?

H_0: Psychological type is not related to efficiency of problem solving using different modes of presentation.

H_a: Psychological type and efficiency are related.

9. Is there a relationship between accuracy and efficiency when solving problems with varying modes of presentation?

H_0: Efficiency of problem solving is not related to accuracy.

H_a: Efficiency and accuracy are related.

Scope and Limitations

This study will compare the effectiveness of graphical, tabular and combined presentations of information in assisting persons of different psychological types to solve problems. The research deals specifically with the Myers-Briggs Type Indicator (MBTI), Form G, in determining the psychological type of the participants. Statements regarding psychological type are limited to preferences indicated on the MBTI, Form G, and no other instrument.

The population surveyed was graduate students at the Air Force Institute of Technology (AFIT), Wright-Patterson Air Force Base, Dayton, Ohio. The students were all military officers and government-employed civilians of comparable grade.

The instrument, in the Appendix, used to survey information format was a photocopy of text and computer designed graphics produced on a dot matrix printer. This research is not designed to measure the influence of differing the quality of information presented, therefore all data presented in the survey are of comparable quality - all originals are from the same dot-matrix printer.

This research also does not attempt to study the effect of subjects with different psychological types solving different types of problems. The constraints and assumptions of all the seven problems used in the survey are identical, the only changing variables between the problems are the numerical amounts of the data and the mode of presentation of the data.

Summary

This chapter discussed the idea of individual differences influencing the effectiveness of different modes of presentation. The research problem and related research questions with hypotheses were presented. The scope and limitations for the study were given. The next chapter gives a review and discussion of psychological type and Management Information Systems and how the two issues are related to the mode of presentation of information.

II. Literature Review

This chapter starts with a description of psychological types as theorized by Carl J. Jung. Jung's theory provided the basis for the formulation and interpretation of the Myers-Briggs Type Indicator (MBTI). The MBTI is then discussed with attention given to the type categories, and a description of types pertinent to this research. Management Information Systems (MIS) is then defined, with emphasis given to the issue of human-computer interface. Lastly the use of the MBTI in MIS research is discussed, with support for its exclusive use in this type of research cited.

Jung's Theory of Psychological Type

Jung put forth a general description of psychological types in his writings. He not only identified the groupings of psychological types, but also the interactions of the different tendencies found in each individual. Jung's typology is based on his years of clinical research and personal observations (Jung,1923).

Jung observed that people were similar in some ways and different in others. He felt that the differences were due to more than mere chance. His observations led him to believe that people differ in three general areas - orientation, perception, and evaluation (Jung, 1923:178-180).

The area of orientation is characterized by the way a person prefers to focus or direct their orientation. An individual's orientation may be internal (subjective) or external (objective).

Persons with a predominately external orientation (extravert) will allow the environment to influence their views more than a person with internal orientation (introvert). Conversely, to a greater extent than extraverts, a person with a preference for introversion will make decisions, perceive things, and act in a way that is influenced by their own feelings and views. An extravert prefers to act on stimuli from the senses, while the introvert prefers introspection. Jung stressed that none of the types are "right" or "wrong", just different from each other (Jung, 1923:182-183,229-234).

The second main area of type identified by Jung is perception. Perception can be thought of as the way a person views objects. Perception, like orientation, is divided into two categories - sensing and intuition. An individual who prefers sensing uses information gained through the five senses to perceive objects in the environment. A sensing person sees things "as they really are" and takes things at "face value". Whereas a sensing type may see something as it really is, an intuitive type will perceive the same thing as it might be. An intuitive-dominant type will see beyond the facts and extrapolate into the hypothetical. A person who prefers intuition will temper what is seen, felt, or heard with an innate "sixth sense". A sensing type may be seen as "realistic" while an intuitive may be labeled an "innovator". Jung recognized that everyone is, to varying degrees, a combination of all types - even the strong sensing type will possess and even demonstrate some intuition, and the same is true for other types (Jung, 1923:215-217,220-222,252-255,258-261).

The third main psychological function identified by Jung is judging. Judging refers to how a person prefers to judge or evaluate objects and events (Jung, 1923:212-213). Judging, too, is a dichotomy of categories - thinking and feeling. An individual who prefers thinking tends to be logical and impersonal when making conclusions. The thinking individual may appear detached and without emotion to a feeling person. A person who prefers feeling will interject a personal evaluation when judging. This manifests itself in decisions slanted by subjective overtones. Events and objects will be good or bad, pleasant or unpleasant to a feeling person, as opposed to the thinking person's logical and impersonal findings (Jung, 1923:192-215,237-252).

Jung's typology uses dominant traits in each of the three main psychological functions to develop a heuristic model for predicting and observing the behavior and attitudes of persons. Extraversion/introversion, sensing/intuition, and thinking/feeling are the three dichotomies of traits Jung identified. Every person has all the traits present in their emotional make-up to some degree, but it is the dominance and interactions of types that make a person's behavior predictable (Jung, 1923:178-187,229-237).

Myers-Briggs Type Indicator (MBTI)

Jung's theory of type is put into practice with the Myers-Briggs Type Indicator (MBTI). The MBTI expands and operationalizes Jung's work on psychological type.

The MBTI is a questionnaire that measures preferences. The questionnaire was researched and developed by Isabel Myers and her mother Katherine Briggs. Inspired by the works of Jung and the

teachings of her mother, Myers compiled an extensive data base of answers to various questions. This task culminated in a workable way of putting Jung's typology to practical use (Myers, 1980:xi).
The MBTI measures the three main dichotomies theorized by Jung, and adds a fourth, judgement/perception (Myers and McCaulley, 1985:13).

This fourth dichotomy is not explicitly addressed by Jung in his "Psychological Types" treatise (Jung, 1923:178-269; Myers and McCaulley, 1985:11). Although not explicitly cited by Jung, this fourth main function does help clarify how a person deals with the outer world and identifies the dominant function (Myers and McCaulley, 1985:13). The person that prefers judgement will tend to shut off the inputs from the outside and make a decision on the evidence received thus far. An individual who demonstrates the judgement trait will see time as a resource to be controlled and set into order. In contrast, individuals with a preference for perception sees time as more of a hindrance and live life more spontaneously (Campbell, 1987). A person who prefers perception will seek to understand life and keep an open mind when possible. The perception individual will prefer a flexible lifestyle, while the judgement person will prefer order (Myers, 1980:8-9; Myers and McCaulley, 1985:13-14).

There are situations in life that demand judgements to be made, and some which force perception - both judgement and perception dominant individuals are able to react appropriately. The difference in the preferred dominant traits occur when the situation allows a choice between judgement and preference to be made (Jung, 1923:266-267).
Myers discussed the prevalence of dominant types in individuals by

explaining that a preference for one type over another develops early in life and becomes more developed than the neglected, opposite trait (Myers, 1980:4). Preference for types comes from continued use, reliance, and success with a dominant type over time.

For the purpose of this research the psychological types used in the statistical analysis will be combined into four groups. This is accomplished by using the inner dichotomies - sensing/intuition (SN) and thinking/feeling (TF). This grouping is done because these two inner dichotomies sufficiently indicate the problem-solving style of the subjects (Mason and Mitroff, 1981:113).

Paul Nutt summarized the influences on problem solving of the SN and TF groupings in his recent paper on decision style:

> These scales determine an individual's preference for types of data and ways to process the data to reach decisions. Either sensing or intuition can be used to acquire information. A sensing (S) individual prefers hard data that deals in specifics wheras the intuitive (N) looks for holistic information which describes hypothetical possibilities and accepts qualitative and subjective information. The sensing person decomposes while the intuitive looks for the gestalt. Thinking and Feeling approaches can be used to reach a decision. . . Thinking generalizes and feeling personalizes [Nutt, 1985:2-3].

A full description of the four type groupings are presented in the next section.

Descriptions of Groupings of Psychological Type

By using only the inner two dichotomies to describe the data, four groups are formed: ST (sensing plus thinking); SF (sensing plus feeling); NF (intuition plus feeling); and NT (intuition plus thinking). Each combination is unique, yet each shares some common attributes with combinations that share one of the same preferences. The interaction

between preferred ways of perceiving and judging make each group unique (Myers, 1980:4).

Sensing Plus Thinking (ST). The ST individuals gather data mainly from their senses (S) and judge by thinking (T), they can be described as the practical, matter-of-fact types. The main focus of ST types are facts, and they act on these facts with impersonal, step-by-step analysis. Persons preferring ST are more scientific in approach, and attend to details more than the other groups (Mason and Mitroff, 1981:113; Myers and McCaulley, 1985:33; Myers, 1980:5).

The characteristics of type preference can be explained further by comparing the percentages of type found in the general population with percentages found in particular jobs. For instance, approximately 56.3% of males and 27.5% of females of the general population are ST according to the SRI International Values and Lifestyles (VALS) Program sample of a cross-section of Americans (n=1,105). Comparing those percentages with ST types in particular chosen occupations: 50.5% of bank officers and financial managers (data oriented); and only 7.21% of writers, artists, entertainers, and agents (non-data oriented) (McCaulley and others, 1985:6-7; Myers and McCaulley, 1985:253-255).

Sensing Plus Feeling (SF). Those preferring SF rely on their senses (S) to get information and act on the information with feeling (F), these individuals are usually the sympathetic and friendly types. Facts are the main focus of SF types, judged with personal warmth. These individuals tend to be humanistic about particulars, and attend to individual concerns (Myers and McCaulley, 1985:33-34; Mason and Mitroff, 1981:113).

The SRI VALS sample had 16.6% of the males and 50.5% of the females showing a preference for SF. Of those individuals sampled from the sales and customer relations field (helpful), 81% were SF types, and only 5% of college science students (data and logic) were SF (Myers, 1980:159; McCaulley and others, 1985:6,7).

Intuition Plus Feeling (NF). Those preferring possibilities over facts and handle them with personal warmth are NF types. People preferring NF may be considered the enthusiastic and insightful types. The NF individual seeks to understand relationships and interactions, with the focus on people. They are interested in the patterns beneath the immediate facts, with their judgement dominated with feeling (Keirsey and Bates, 1978:66; Myers and McCaulley, 1985:35).

The SRI VALS sample shows 8.7% of males and 15.5% of females as preferring NF type. Sixty-five per cent of the creative writers (insightful) sampled were NF, while only four per cent of the accountants (data oriented) showed a preferrence for NF (McCaulley and others, 1985:6,7; Myers, 1980:159-160).

Intuition Plus Thinking (NT). Persons who prefer NT gather information primarily through intuition (N), and prefer to be logical and thinking (T) when judging. The NT types tend to be logical and ingenious. They focus on the possibilities and patterns, and analyze with impersonal logic (Myers and McCaulley, 1985:35).

The SRI VAL sample showed 18.4% of the males and 6.5% of the females preferred NT. Of the research scientists sampled (logic and intuition), 77% were NT types, and only 9% of the accountants (data) (McCaulley and others, 1985:6,7; Myers, 1980:159-160).

The four groupings of type described here will be used to analyze the data from this research. The groupings represent uniquely different cognitive styles, each with its own method of approaching problem solving.

Management Information Systems

The term Management Information Systems (MIS) refers to all processes, usually confined to an organization, that collect, measure, categorize, store, and report information. Under the umbrella of MIS fall the obvious, such as computer systems, and the not-so-obvious, such as the vast informal communication networks between employees. As noted in the introduction, this research focuses on the idea of managers as information processors. This particular stage of the MIS involves the format used to present information to the manager and the use of that information by the manager to make decisions.

Previous research in the area of information presentation with respect to MIS has focused on comparisons between written and computer monitor presentations of information and decision style and how they interact to affect decision-making (Lucas, 1981) and the study of how the use of color interrelates with the ways of presenting information (Benbasat and Dexter, 1986). There has been a study by Lusk and Kersnick (1979) which touched on the essence of this study, its methods and findings are discussed here.

The Lusk and Kersnick study classified persons as being either high or low analytic based on results from the Embedded Figures Test. The information was then presented in five different forms - raw data, tabular report, and three different graphical representations of the

data. The Lusk and Kersnick study concluded with three MIS design principles: 1) Personnel selection and task assignment functions are crucial to the success of a MIS design regardless of report format used - the results showed that certain psychological types were more efficient at solving the problems given, regardless of the method of presentation of the information; 2) Performance will not improve if different reports are given to the individual difference groups - the study showed no significant correlation between psychological type (as measured by the Embedded Figures Test) and the method of presentation of information; and 3) Report formats do affect performance and the format which is perceived as least complex is best - The study required the subjects to rank the presentation methods in order of perceived complexity, this order did correlate with the effectiveness of the use of the different methods of presentation (Lusk and Kersnick, 1979).

These conclusions, especially the second stating there is no correlation between report format and psychological type, seem to disagree with the hypothesis from Mason and Mitroff stated earlier in this study which said that managers could benefit by tailoring data to their psychological type. Mason and Mitroff specifically suggested the following as a principle to be used as a guide for subsequent research:

> Managers need 'information' that is geared to their psychology not to that of their designers. This places a heavy burden on the designers of MIS. They must not only find out what information the manager actually needs, but the designers must also find out which mode of displaying the information is most amenable to the manager's psychology [Mason and Mitroff, 1973:pg 485].

Lucas agreed with Mason and Mitroff, as opposed to Lusk and Kersnick, in the conclusions of his experiment in computer based graphics (Lucas, 1981:767).

Lucas divided his subjects into two groups according to their "... predominant approach to problem solving" (Lucas,1981:762). The test Lucas used grouped those subjects who tended to look at entire problems and labeled them as heuristics. Those who focused most on details were labeled as analytics (Lucas, 1981:760). Lucas studied middle to upper level managers on their preferences and effectiveness when presented different types of information. There was a significant correlation found between decision style and success with different types of information. The heuristic decision-makers were more accurate with graphical data when compared to heuristic types given tabular data. There was no significant differences noted for the analytic types (Lucas, 1981:766).

Several researchers of MIS have recommended additional studies be done in the area of individual differences (thru cognitive psychology or otherwise) and how they affect decision-making efficiency (Benbasat and Dexter, 1986; Card and Newell, 1983; Dickson and others, 1977; Ives and others, 1980; Jarvenpaa and others, 1985; Lucas, 1981; Lusk & Kersnick, 1979; Mason & Mitroff, 1973; Zmud, 1979). One way of identifying individual differences is through identification of cognitive style.

Decision-making relies heavily on the cognitive processes. Managers must process symbolic information (perception) and then use the information to solve problems and reach decisions (judgement) (Card and Newell, 1983:15).

Management Information Systems are used to aid decision-making. The way that information is presented to the decision-maker influences the effectiveness of the decision. This research attempts to make a correlation between the personality type of the decision-maker and the varying effectiveness of different methods of presenting data. The following section will examine the connection between MIS research and personality type research.

Personality Type and MIS

As the Lucas study cited in the previous section points out, there seems to be a correlation between personality type and the mode of presentation of data used for decision-making. The Lucas study measured personality type by classifying individuals according to problem solving style. The study by Lusk and Kersnick used the Embedded Figures Test to measure type. The question arises: Is there a single personality-type measuring device which should be used in the area of MIS?

Newell and Card suggested that the more technically oriented computer science will tend to drive out the science of psychology in the area of human-computer interaction research (Newell and Card, 1985:209). They theorize this is happening because the "qualitative factors are left aside when they do not fit into the technical analysis" (Newell and Card, 1985:211). In order to overcome this paradigm (psychology is useful, but it doesn't always fit in the models developed), the tools used to measure psychology must be more precise to compete with the qualitatively-oriented computer science.

In a paper presented to the Second International Conference on Information Systems in 1981, Keen and Bronsema make a strong proposal for the exclusive use of the Myers-Briggs Type Indicator (MBTI) in MIS research. Their work traced the history of cognitive style research in MIS from 1964 to 1981 and concluded that the MBTI reasonably meets all tests of validity (Keen and Bronsema, 1981:21). The Jungian typology and particularly the MBTI has been recognized as ". . .the most suggestive of research hypotheses. . ." for study in the MIS field in connection with psychological types and individual differences (Mason and Mitroff, 1973:476).

Based on the four types described earlier, certain general hypotheses can be made regarding the interaction of type and presentation of information within an MIS. The ST type of manager will most likely excel when the problem calls for a logical, impersonal judgement and the facts are explicitly laid out. The SF manager will also prefer to have the facts available for analysis, but this manager will excel in problems presented with a personal view. The impact the decision has on the individual will dominate the judgement.

The manager preferring NT will search for the patterns or possibilities in lieu of the bare facts, and will follow a logical, methodical pattern to arrive at a decision using the perceived patterns found in the data. The NF manager will also excel when data is presented in a way that patterns and possibilities are evident, but will take a more personal view when solving the problem, using feelings and morals to decide the answer.

Summary

This chapter explored the Jungian typology as the basis for the MBTI. The particular aspects of the MBTI were then discussed with a description of the types pertinent to this research. Management Information Systems were then discussed, with the emphasis on the previous research conducted in the area of individual differences. And finally the support for the use of the MBTI in MIS research was given. The next chapter will discuss the methodology used in testing the research problem.

III. Methodology

This chapter discusses the methodology followed in the research to answer the central and subsidiary research questions and test the hypotheses. The chapter begins with a description of the population and research design. Next, the surveys used for data collection are discussed. The main statistical tests used are presented. The chapter ends with a discussion of the modeling procedure followed.

Population and Research Design

The population used in the research was graduate students from the classes graduating in September and December of 1988 from the Air Force Institute of Technology. The students attend the 15-to-18 month program in-residence and then return to mid-level management positions in the government.

The population was tested for psychological type using the Myers-Briggs Type Indicator, Form G. The information presentation data was collected using a survey designed for this research. A description of the surveys and the methods used to administer the surveys are discussed in the following section.

Surveys

Two surveys were used in this study, the Myers-Briggs Type Indicator (MBTI), Form G, and the Information Presentation Mode Survey (IPMS).

The Form G of the MBTI was given to the subjects following the general guidelines from Manual: A Guide to the Development and Use of

the Myers-Briggs Type Indicator (Myers and McCaulley, 1985). The preference results of the MBTI are spread among 16 categories in a Type Distribution Matrix. Some cells are likly to be represented in the sample, while others may be empty. In order to obtain results of statistical significance, the Type Distribution Matrix was condensed according to the S/N and T/F dichotomies (ST, SF, NT, NF). Each subject's sex was also noted, to better compare the sample population with a type population representing the general population.

The Information Presentation Mode Survey (IPMS) was developed specifically for this research to gather data regarding mode of presentation of information. The subjects were asked to compute answers to seven problems. The problems included different data values and consisted of the following presentation formats: line chart, line chart with tabular data, bar chart, bar chart with tabular data, pie chart, pie chart with tabular data, and tabular data alone. The order of the problems varied randomly, in order to minimize any learning curve influence. The subjects also ranked their preferences for the way information was presented.

Modeling

Data collected from the two surveys were analyzed using the computer software package Statistical Analysis System (SAS) as implemented on the VAX/VMS computer. The main procedures used in examining the relationship of the two pertinent factors (personality type and mode of presentation) were the F statistic, Chi-square analysis and Duncan's Multiple Range Test.

All hypotheses and statistical analysis were tested to an alpha of 0.05 in order to minimize the likelihood of commiting a Type I error (rejecting the null hypotheses when it is true) to 5 per cent.

Summary

This chapter outlined the method used to complete the research. The general outline of the survey instruments, modeling and statistical analysis followed.

The next chapter analyzes and discusses the results of the statistical analysis performed on the collected data.

IV. Data Analysis and Discussion

This chapter presents an analysis and discussion of the data obtained for this research. The nine subsidiary research questions and their corresponding null hypotheses are discussed and analyzed.

Subsidiary Research Question 1

The first subsidiary question asks if the sample type distribution is different from the general public. The answer to the question identifies whether the sample is unique or not as measured by the Myers-Briggs Type Indicator (MBTI). The first question is:

1. Do the subjects have different psychological types than the general public?

The answer to this question will identify type biases of the sample.

For the first subsidiary hypothesis the sample type distribution was compared to a type distribution representing the general public. The SRI Values and Lifestyles (VALS) sample type distribution was chosen for this comparison (McCaulley and others, 1985). The reasons this distribution was chosen for comparison are discussed below.

The VALS type distribution is from a population of over 1,000 people gathered as part of an ongoing nationwide research project. According to McCaulley, Macdaid and Kainz the VALS distribution is based on a sample that ". . .is the closest currently available on a nationwide random basis, but is somewhat biased toward more affluent groups, since the data are used for marketing surveys" (McCaulley and

others, 1985:5). The alledged bias should not confound the comparison with the research sample's type distribution, since the research sample subjects are all currently employed in government middle management positions similar to the VALS estimate of the general population.

The VALS distribution for male and female are found (rounded to the nearest whole number) in Table 1. Notice that male and female percentages are shown because the figures for the total population are dependent upon the relative mix of genders. For example, if the sample consists of more male than female, then it is likely that the percent of the total population that prefer Thinking will be closer to 75% (male) than 34% (female).

TABLE 1

TYPE DISTRIBUTION OF VALS SAMPLE DIVIDED BY GENDER AND MAJOR DICHOTOMIES

	% Male	% Female		% Male	% Female
Extraversion:	36	43	Introversion:	64	57
Sensing :	73	78	Intuition :	27	22
Thinking :	75	34	Feeling :	25	64
Judgement :	70	64	Perception :	30	36

(McCaulley and others, 1985)

To compensate for this potential bias, the total percentage figures used to compare the research sample's type distribution to the VALS have been adjusted. The comparisons have been mathematicall

adjusted to conform to the relative mix of males and females found in the research sample (85.9% male and 14.1% female). In the actual VALS sample there were 59.6% female and 40.4% male respondents (McCaulley and others, 1985:5).

Comparison of the VALS and Research Sample Type

The type distribution table must be measured for the sample in order to begin to answer this question. Data for this discussion were gathered using the Myers-Briggs Type Indicator (MBTI), Form G. All subjects were volunteers. Sixty-four students who completed and returned an MBTI participated in the study. (64).

Due to the design of the MBTI, the letter score is considered the most important aspect of the testing results. The MBTI was designed so that values are most accurate when measured near the center (close to zero) rather than at the extremes of each index (Keen and Bronsema, 1981:33). This type of construction and reliance on the letter rather than the numerical score make parametric statistical analysis of limited use, unless type is used to group like subjects. Keen and Bronsema stated that most research has relied on showing observed to expected frequencies based on large samples and many studies report no tests of significance (Keen and Bronsema, 1981:33). Therefore, subjects are grouped by like type for this study, and tests of significance are calculated when appropriate.

The MBTI preferences for the 64 participants in the study resulted in the full type distribution matrix shown in Table 2. The following is a discussion of the relevance of the data presented in the table.

Table 2 is the research sample frequency distribution by male and female categories. Referencing the table reveals that two cells have zero observations and two cells have over ten. This uneven distribution within the table makes the effects of the over-represented cells overwhelm those cells that are under-represented. For instance, if the individuals who prefer S (the left two columns of Table 2) show a preference toward facts and numbers, and the N types (the other half of the table) prefer graphs that show the whole scenario, then the distribution as a whole will show a strong preference toward facts and numbers. This is true since the S types outnumber the N types by over two to one (S=43 , N=21).

Some generalizations that can be made about the relative distribution of types in the research sample are as follows. Since the S type outnumbers the N type, the population will be less introspective and prefer to gather information from outside facts. The relative lack of F types (F=14 , T=50) will result in more preference for logical and impersonal judgements. The over-represented J population (J=43 , P=21) will mean the population prefers order in contrast to flexibility.

The distribution of the research sample is shown condensed into the four relevant groups representing cognitive style in Table 3. In reviewing Table 3 it can be seen that the groups are not equal. The Sensing-Thinking group accounts for over half (51.5%) of all subjects and the Intuitive-Feeling group less than 7% (6.3%).

Table 2

AFIT MALE AND FEMALE MBTI TYPE DISTRIBUTION

N=64

(Male: 55; Female: 9)

	ISTJ	ISFJ	INFJ	INTJ
Male	10	4	-	4
Female	3	-	-	-
Total	13	4	0	4

	ISTP	ISFP	INFJ	INTP
Male	6	1	1	6
Female	-	-	-	-
Total	6	1	1	6

	ESTP	ESFP	ENFP	ENTP
Male	1	2	-	1
Female	2	1	-	-
Total	3	3	0	1

	ESTJ	ESFJ	ENFJ	ENTJ
Male	11	1	2	5
Female	-	1	1	1
Total	11	2	3	6

TABLE 3

AFIT TYPE DISTRIBUTION BY COGNITIVE STYLE

Type Group	n	Percent
Sensing-Thinking (ST)	33	51.5
Sensing-Feeling (SF)	10	15.6
Intuitive-Thinking (NT)	17	26.6
Intuitive-Feeling (NF)	4	6.3

TABLE 4

AFIT TO VALS COMPARISON OF COGNITIVE STYLE BY EXPECTED AND OBSERVED NUMBERS

Type Group	Expected n	Observed n
ST	33.5	33
SF	13.7	10
NT	10.7	17
NF	6.2	4

The expected values of ST, SF, NT and NF were calculated and compared with observed values. The expected values were computed by taking the research sample size (64) and multiplying it by the VALS total percent for each of the four groups (after compensating for the difference in gender percentages). The results are shown in Table 4 above. It can be seen that

the SF and NF are under-represented in the research sample and the NT group is over-represented.

The Chi-square statistic was used to compare the expected values and the observed values with a statistical significance. The Chi-square statistic uses the differences between the corresonding expected and observed values to arrive at a test statistic. The following formula was used in this study to arrive at a Chi-square test statistic:

$$X^2 = \frac{(f_o - f_E)^2}{f_E}$$

where X^2 = Chi-square test statistic

f_o = observed frequency

f_E = expected frequency

This test statistic is compared to Chi-square values at given significance levels and degrees of freedom. If the test statistic is smaller than the Chi-square value, the null hypothesis being tested can be accepted (McClave and Benson, 1985:790-794).

The Chi-square analysis was performed for the null hypothesis:

H_0: The subjects have the same distribution of psychological types as the general public.

The test statistic, 5.49, was compared at a .05 alpha level of significance and 3 degrees of freedom. The test statistic was found to be inside the acceptance region of $X^2 < 7.815$. Therefore, the null hypothesis that the two distributions are the same is not rejected. This finding must be caveated by stating that the Chi-square computation assumes a minimum cell

size of 5. The observed n of 4 in the NF cell makes the results suspect of possible error. However, the strength of the statistic may tend to overshadow the possibility of error.

Another comparison of the type distribution is made on the basis of the Selection Ratio (SR). The SR for each group represents a ratio of the percentages of the two distributions, the closer the SR is to one, the nearer the two distributions are to being equivalent. If the SR is over one, the group is over-represented. Under-representation is indicated by an SR less than one. Again, the SR has been computed based on equivalent percentages of males and females for each distribution, the results are found in Table 5.

TABLE 5

AFIT SELECTION RATIOS DIVIDED BY COGNITIVE STYLE

Type Group	AFIT Group SR
ST	.998
SF	.729
NT	.649
NF	1.59

In reviewing the Selection Ratios, note that the ST group is closest to the value of one and is more representative of the expected amount. The NF, NT and SF type groups show less similarity to expected distributions.

These differences should therefore be taken into account in all analyses and conclusions.

Subsidiary Question 2

Subsidiary Question 2 concerns the relationship between accurately computed solutions and particular modes of data presentation. In order to show that a relationship exists, the accuracy of answers must vary.

The second subsidiary question is:

2. Are subjects more accurate using some modes of presentation when compared to other modes?

If this relationship is shown to exist, the null hypothesis would not be accepted.

The null hypothesis states:

H_0: Subjects have equal accuracy when solving problems using different modes of presentation.

The data used to test this subsidiary question were gathered using the Information Presentation Mode Survey (IPMS) (See Appendix). The IPMS was developed specifically for this research using the "Brand Manager's Allocation Problem" as a basis for the problem type (McIntyre, 1982; Benbasat and Dexter, 1986). The task asked the subjects to attempt to maximize total profit by allocating 20 stores among 3 cities for each of 7 problems. Each of the three cities were represented by showing the relationship between profit and the number of stores (1 to 20) allocated to the city. Seven problems were given to each subject. All assumptions and scenarios were the same for each problem, with the exception of the varied information presentation format and profit to number of stores relationships.

The subjects received seven different presentation modes each. The order the problems were arranged was varied randomly:

- Line graph
- Line graph with equivalent numerical data
- Bar graph
- Bar graph with equivalent numerical data
- Pie chart
- Pie chart with equivalent numerical data
- Numerical data

The graphical data corresponded to the tabular data on a one-to-one basis, except with the pie charts, which are based on intervals of two. The tabular data contains exact values, which must be approximated in the graphical data. The combined reports contain all the information found in each mode of presentation in identical formats (see Appendix for a copy of the IPMS).

The SAS statistical subprogram used for subsidiary questions two thru nine was the General Linear Models with Repeated Measures Design. This subprogram allowed the data to be grouped into classes (by psychological type or mode of presentation), and then sample multiple coefficients of determination, R^2, and/or F values were used to show relationships. If the R^2 and F values were not meaningful, the post-test of Duncan's Multiple Range Test was computed. An alpha of .05 level of significance was used.

The sample multiple coefficient of determination, R^2, is the fraction of sample variation of the independent variable(s) attributable to the dependent variable(s). Thus, an R^2 equal to 0 means there is no relationship between the variables, and an R^2 of 1 means that there is a one-to-one

relationship between the two (McClave and Benson, 1985:467-469). In addition to the R^2, the F value is used to show relationships in this study.

The F value is based upon a comparison of variances. A subject's score varies from the mean (average) for two reasons: Variation due to the fact the subject is an individual; and variation due to the group which the subject is a member (this variance is shared by all members of the group). The F value is computed by dividing the variation due to subject differences by the variation due to group differences. If the variation found within the groups is large when compared to the variation between the groups, the F value will be large. The null hypothesis states that the means of the groups are the same would be more likely to be rejected (depending on the level of significance) (Cody and Smith, 1985:95-100). In order to determine the level of significance, the probability of obtaining an F value larger than the one computed is determined. This probability is the level of significance for the F value.

If the R^2 and/or the F value show no significance, Duncan's Multiple Range Test (Duncan's Test) is used in this study as another test for relationships. The Duncan's Test statistically shows if the ranges between the means of all possible pairs of variables are significant. Each mean is first compared with the largest mean to see if they fall inside a significant range, then all the means are compared to the next largest, and so on until all possible pairs have been tested. If means are close enough to be related, given a certain level of significance, then the variables are shown grouped together by sharing a common vertical line to their right. This test controls for Type I (experiment) error and may be used to prove the

non-acceptance of the null hypotheses that state that a set of means are not related at given significant levels.

In order to test if there was a relationship, accuracy was measured by the number of dollars difference between the subject's answer and the optimal profit for each problem. For example, if the true maximum profit determined for the problem was $1,000 and the most profit the subject could come up with was $800, then the error is $200. This error is inversely related to accuracy, that is, when error is very large, the answer is least accurate.

The error was modeled against the problems using the F value and Duncan's Multiple Range Test. The relationship between accuracy and presentation mode was determined by modeling the error against the problems. Error, as explained above, is negative accuracy. The presentation mode of data was the only dependent variable changed between the problems, so any variation in accuracy between the problems is due to the changed mode of presentation.

Computation of the Relationship Between Accuracy and Presentation Mode. The F value computed when accuracy (the dependent variable) was modeled against the problem (the independent variable) was 3.08 (with 6 degrees of freedom). The probability of obtaining an F value greater than 3.08 is .059. This means the F value is outside the .05 level of significance being used for this study. Therefore on the basis of this test alone, the null hypothesis can not be rejected. To further test the relationship between accuracy and mode of presentation of information Duncan's Test was performed at the .05 level of significance.

The results of the Duncan's Test are shown in Table 6. The mean error (average negative accuracy) for each of the problem types is noted. The lines

beneath the Duncan's Grouping show the relationships between the means of the error for the different problems. For example, the first and third methods of presentation are not significantly different (they share the same line), while the third and last methods are different (different lines).

TABLE 6

COMPARISON OF ACCURACY AND METHOD OF PRESENTATION USING DUNCAN'S MULTIPLE RANGE TEST WITH MEAN DOLLAR ERROR

Method of Presentation	Mean Dollar Error	Duncan's Grouping
Line Graph Alone	133.30	
Line Graph with Tabular	130.02	
Bar Graph with Tabular	124.05	
Tabular Alone	101.64	
Pie Graph Alone	90.30	
Pie Graph with Tabular	78.03	
Bar Graph Alone	73.72	

Overall the subjects were most accurate with the bar graph alone. The mean error of $ 73.72 indicates the highest level of accuracy when the bar graph was used for problem solution. There is a significant decrease in accuracy when tabular figures are used to supplement the bar graph and line graph. Mean errors increase when tabular data are introduced. The subjects

were least accurate using the line graph alone for problem solution as noted by the largest error mean $ 133.30.

The analysis shows that a relationship exists between accuracy (as measured by mean error) and the method of presentation of information. Accuracy is least with line graph and greatest with bar graph. Tabular data alone is shown as mid-range in accuracy, while pie graphs are at the upper region of accuracy. When tabular data are combined with line and bar graphs, accuracy decreases. Tabular data is seen as having a positive affect when combined with pie graphs.

Subsidiary Question 3

The third subsidiary question asks if psychological type is related to accuracy. For a relationship to exist, the accuracy must vary by type.

The third subsidiary question is:

3. Is the psychological type of a subject related to the accuracy of problem solving when using different modes of presentation?

In order to show that there is a relationship between accuracy with certain presentation modes and psychological type, it first must be shown that accuracy varies between presentation modes. This relationship is evidenced in the previous section. Given that accuracy varies between presentation modes, the question is does type influence the variance in accuracy.

To test for relationships, accuracy (error) was modeled against type alone and the combination of type and problem. This procedure isolated the varying accuracies each type achieved on a given problem and compared it to other types. The null hypothesis was then tested.

The null hypothesis states:

H_0: The psychological type of a subject has no relation to the accuracy of problem solving when using different modes of presentation of information.

When the null hypothesis was tested an F value of 0.87 was found with 27 degrees of freedom, this F value is significant to the .6589 level. Since this exceeds the .05 level of significance, the null hypothesis of no relationship may not be rejected. Furthermore, the R^2 statistic showed only 5.28% of the variation in accuracy could be attributed to the model.

Additional statistical tests were run using SAS to find any correlation for individual types and the problems which they were most and least accurate. However, no significance could be drawn. These results could occur for two possible reasons. The first reason is that there is no relationship between the variables, in which case it is correct to accept the null hypothesis. The second reason is that the small sample size may be limiting the strength of an existing relationship. It is not possible to tell which is the correct reason, given the current data.

The means in Table 7 are shown for cursory analysis of trends found in the data, and are offered for informational purposes. No statistical significance has been associated with the data in Table 7.

Subsidiary Question 4

The fourth subsidiary question concerns the relationship between preference and mode of data presentation. The answer to this question will show if there are significant differences between the preference ranks of the seven different modes of presentation.

TABLE 7

AFIT MEAN DOLLAR ERROR AND RELATIVE RANKINGS BY TYPE
DIVIDED BY MODE OF PRESENTATION OF INFORMATION

	MEAN DOLLAR ERRORS / RANK			
Method of Presentation	ST	SF	NT	NF
Line Graph Alone	178/7	98/7	69/3	124/5
Line Graph with Tabular	166/5	48/3	134/7	20/1
Bar Graph Alone	85/1	35/1	59/1	146/6
Bar Graph with Tabular	171/6	77/6	79/5	50/2
Pie Chart Alone	90/2	55/4	93/6	170/7
Pie Chart with Tabular	100/3	40/2	64/2	51/3
Tabular Alone	132/4	62/5	75/4	62/4

The fourth subsidiary question is:

4. Do subjects prefer some modes of presentation over other modes?

If this relationship is proven to exist, the null hypothesis will not be accepted.

The null hypothesis for this question is:

H_0: Subjects have equal preference for all modes of presentation of information.

The data used in this subsidiary question came from the Information Presentation Mode Survey (IPMS). The subjects used each mode of presentation in problem solving and then ranked their preferences for the modes from best

to worst. The numbers 1 to 7 were used to indicate preferences, with each number used only once. This procedure ensured each subject ranked all seven modes, and that each mode received a different rank for a given subject. The number 1 was used to indicate most preferred; 7 indicated least preferred.

The data were filled into available spaces by the participants (an example of the IPMS can be found at Appendix) and was hand-transferred into the computer for statistical analysis.

The means of each problem's total preferences were compared together to determine if the means were the same. If the means are the same for all problems, then there is no difference between the preferences of the problems. For example, if the 64 subjects gave an average preference rank of 5 to line graphs, and an average rank of 2 to bar graphs, the difference between the two means would indicate if the preferences were the same or not. A difference of 3, as in this case, would be an indication of varying preferences between line graphs and bar graphs.

Table 8 shows the means and relative ranking of each of the problems. The closer to one the mean is the more it is preferred, and the closer to seven it is the less preferred it is. By reviewing the data, it can be seen that the most preferred mode is line graph with tabular, with a mean preference of 2.33. The least preferred mode is pie chart at a mean value of 5.84. The addition of tabular data to every graphical mode increased the preference, and all combined modes were more preferred than tabular alone.

The means from Table 8 were used to make paired comparisons. Each possible pair of means was tested against the hypothesis that their means were the same. This hypothesis was proven false at a .05 level of significance for 18 pair and true for the following 3 pair: tabular

alone/pie graph with tabular (.59), line graph/bar graph (0.15), line graph with tabular/bar graph with tabular (.07). This comparison testing shows that nearly all the modes are preferred differently from one-another, therefore a relationship does exist between preference and mode of presentation of data.

TABLE 8

AFIT MEAN PREFERENCES AND RELATIVE RANKINGS
DIVIDED BY MODE OF PRESENTATION OF INFORMATION

Method of Presentation	MEAN PREFERENCE	RANK
Line Graph	4.36	5
Line Graph with Tabular	2.33	1
Bar Graph	4.83	6
Bar Graph with Tabular	2.92	2
Pie Chart	5.84	7
Pie Chart with Tabular	3.61	3
Tabular Alone	3.78	4

Subsidiary Question 5

The fifth question asks if the psychological type of a subject is related to the preferences chosen for the different modes of presentation. For a relationship to exist between psychological type and preference, preference must vary by type.

The fifth subsidiary question is:

5. Is the psychological type of a subject related to the preferred mode of presentation of information?

The previous section showed that preference rankings do vary between presentation modes. The analysis for this question will show if any of the variance of preference can be shown to exist due to differences in psychological type.

To test the null hypothesis, preference (by presentation mode) was modeled against type. By combining preference and presentation mode, the influence of presentation mode alone will not influence the results.

The null hypothesis states:

H_0: The psychological type of a subject has no relation to the preferred mode of presentation.

When the null hypothesis was tested, an F value of .84 was determined, with 47 degrees of freedom. The significance of the F value was 0.768, which falls outside the rejection region of .05. The R^2 statistic showed that 8.96% of the variation of the preference could be explianed by the differences in type.

To further test the relationship for significance, Duncan's Test was performed. At an alpha of .05, no differences were found.

The results of this phase of the analysis shows the variance of preference rankings found in the sample is due to something other than psychological type.

Subsidiary Question 6

This subsidiary question is designed to find out if accuracy and preference are related. The subject's ranked preference for a particular mode of presentation is modeled against their success at using the mode in solving problems.

The Subsidiary question is:

6. Are the preference rankings of presentation modes related to their accuracy?

To be able to prove that there exists a relationship between preference and accuracy with respect to problem type two relationships must be shown to exist. First, there must exist a variation in accuracy among the presentation modes. This relationship was shown to exist in subsidiary question two. Furthermore, preference must be shown to vary among the modes of presentation. This relationship was shown to exist in subsidiary question four.

The null hypothesis states:

H_0: The preference for mode of presentation of information is not related to accuracy.

The null hypothesis was tested by modeling accuracy against preference. The F value computed from the model is .64 with 47 degrees of freedom. This F value is significant to the .969 level. Because the significance is greater than this study's .05, the F value does not show the null hypothesis to be rejected. The R^2 statistic shows that 6.99% of the variation in accuracy is due to preference.

Because the F value failed to reject the null hypothesis, Duncan's Test was run. Duncan's Test failed to show any differences between means at the alpha = .05 level.

The analysis for this question shows that a high or low preference for a mode of presentation does not mean that the accuracy will also be high or low. As in the previous question, the research fails to show what, if anything, besides method of presentation of information is influencing the

rank preferences. As noted in Taylor and Benbasat's critique of cognitive style research, there are other probable explanations for the effects attributed to cognitive style. A subject's age, sex, and experience may act as confounding variables to influence the outcome of the research (Taylor and Benbasat, 1980:86). These affects may be present in this research.

Subsidiary Question 7

The seventh subsidiary question asks if there is a relationship between efficiency and presentation mode. For a relationship to exist, accuracy must vary between types of presentation modes.

This subsidiary question is stated:

7. Are subjects more efficient using some modes of presentation when compared to others?

This question requires that efficiency be measured and compared between presentation modes. This was accomplished by assigning time as a measure of efficiency. The IPMS had the subjects self-report the time beginning and time ending for each problem. The number of minutes it took for each problem was then determined and recorded. The minutes were rounded to the nearest minute, with any time less than one minute being recorded as one minute. The number of minutes recorded to complete individual problems varied from 1 to 40.

The null hypothesis states:

H_0 : Subjects have equal efficiency when solving problems using different modes of presentation.

The null hypothesis was tested using F values, R^2, and Duncan's Test. The model tested was minutes against problem types, with the number of minutes as a negative indicator of efficiency. The greater the number of minutes it

took a subject to complete a problem, the less efficient the mode of presentation found in the problem was for that subject.

The F value computed from the model was 2.00 with 6 degrees of freedom. The level of significance shown by the F value was 0.0653. Since 0.0653 is slightly greater than the .05 alpha used in this study, the F value alone can not accept or reject the null hypothesis. The R^2 computed for the model was 0.381, which means that 38.1% of the variation of minutes is due to the problem type. That seems to be a significant amount, but the R^2 statistic does not have a measure of significance, so the Duncan's Test was conducted.

The results show that there are relationships when using the Duncan's Test. Table 9 shows the relationships found at a .05 level of significance. The lines under the Duncan's Grouping show the relationships between the means for the different problems. For example, the first and fourth methods of presentation are not significantly different, while the first and last methods are different.

First, looking at the mean minutes, the data shows the most overall efficient method for presenting data as the line graph alone, with an average of 2.3125 minutes. The most inefficient for the subjects was the tabular alone with a mean of 3.5938 minutes. Note that when tabular data is used in conjunction with graphical, it increases the time spent over graphical alone.

The data suggests that each combined presentation is related to it's graphical-alone counterpart. For example, bar charts and bar charts with tabular are related. Also note that the pie chart alone is not related to any other graphical-alone presentation, the only single-mode presentation it is related to is tabular alone.

TABLE 9

COMPARISON OF EFFICIENCY AND METHOD OF PRESENTATION USING DUNCAN'S MULTIPLE RANGE TEST WITH MEAN MINUTE ERROR

Method of Presentation	Mean Minutes	Duncan's Grouping
Tabular	3.5938	
Pie Graph with Tabular	3.3438	
Pie Graph	2.9063	
Bar Graph with Tabular	2.7656	
Line Graph with Tabular	2.4844	
Bar Graph	2.4688	
Line Graph	2.3125	

The variance of efficiency has been shown to exist at a significant level. The next subsidiary question asks if perhaps some of the variance of effeciency is related to psychological type.

Subsidiary Question 8

The eighth subsidiary question asks if there is a relationship between psychological type and efficiency. The analysis checks for any variance in efficiency that can be related to psychological type. The relationship must be significant at the alpha = .05 level to prove or reject the hypothesis.

This subsidiary question states:

8. Is the psychological type of a subject related to the efficiency of problem solving when using different modes of presentation of information? The variance of efficiency must be proven prior to showing if psychological type has an influence on the variance. This variance has been proven by subsidiary question six.

To test if type and efficiency are related, minutes (negative efficiency) has been modeled against cognitive style (a measure of psychological type). The null hypothesis was then tested.

The null hypothesis states:

H_0: Psychological type is not related to efficiency of problem solving using different modes of presentation.

When the null hypothesis was tested, an F value of .72 with 3 degrees of freedom was calculated. The level of significance associated with the F value is .5382. Since .5382 exceeds the .05 alpha level this study has deemed significant, the null hypothesis can not be rejected on the basis of the F value alone. The R^2 statistic for the model is .0049, which means that 0.49% of the variance in efficiency can be attributed to type. Since neither the F value or the R^2 statistic shows significant relationship, Duncan's test was run.

Duncan's test failed to show any differences between the means at an alpha of .05.

Again, the statistical tests failed to reject the null hypothesis. The efficiency has been shown to vary among presentation modes, and yet the psychological type does not significantly influence this variance. Perhaps

the accuracy and efficiency are related. It is this question that the next section will address.

Subsidiary Question 9

This question is concerned with the variances in both accuracy and efficiency. For a relationship to exist, the variances of efficiency and accuracy must be statistically related at the .05 level or less.

The ninth subsidiary question is:

9. Is there a relationship between accuracy and efficiency when solving problems with varying modes of presentation?

In order to show a relationship between accuracy and efficiency variations, one or both of the variables must have been shown to have significant variance. Accuracy was shown to have variance in the analysis and discussion of subsidiary question two. The efficiency was shown to have variance in the seventh subsidiary question. This question is designed to show if the two variances are related.

The null hypothesis states:

H_0: Efficiency and accuracy of problem solving using varying presentation modes are not related.

The null hypothesis will be tested by modeling accuracy against efficiency. The model will be tested at the .05 level of significance.

The F value computed for the model was 3.05, with 17 degrees of freedom. The significance associated with this F value is .0001. Since .0001 is smaller than .05, the null hypothesis may be rejected. This shows that there is a relationship between accuracy and efficiency when problem solving using varying modes of presentation of information.

The strength of the F value shows that, even though both variables vary

vary among different modes of presentation, they have common variances as well.

Summary

This chapter outlined the research questions and discussed the data associated with each. In addition to the discussion, the analysis of the data was presented.

The next chapter discusses the conclusions based on the discussion and analysis of the data. Also covered in the next chapter are recommendations regarding the research.

V. Conclusions and Recommendations

This chapter presents the conclusions reached as a result of this research and recommendations concerning the findings. First, the conclusions for the nine subsidiary questions and the central research question are discussed. And last, recommendations are made.

Conclusions

The answer to the central research question is determined by the results of the subsidiary questions.

Question 1. The hypothesis that there is no difference between the type distribution of the sample and the general public is accepted. When compared to a type distribution of a random sample of Americans, no significant differences were found.

The fact that the two type distributions are statistically similar means that it is possible to generalize the findings of the research to the general population. This should be done only with caution, however, due to the small sample size of this research. The sample size (64) and particularly the small size of the expected and observed NF type (expected = 6.2 , observed = 1) increases the potential for error when generalizations are made.

Question 2. The hypothesis that accuracy will not vary when using different modes of presentation is not accepted. The results of the analysis show a significant difference among two groups of presentation modes. When subjects used line graphs, line graphs with tabular and bar graphs with tabular their accuracy was significantly less. The opposite is true of pie

graph with tabular and bar graph alone. Accuracy with these two presentation types was significantly better.

The findings of the relationship between mode of data and accuracy has definite design implications for Management Information Systems (MIS). For the type of problem used in this research the information given to a decision-maker should be as a pie graph with tabular data beside or as a bar graph alone. If accuracy (as opposed to speed) is the goal of the decision, then line graph alone should be avoided.

Question 3. The hypothesis that psychological type has no relation to accuracy is accepted. Based on the analysis of data, the variation of accuracy can not be attributed to psychological type. The statistical data analysis does not show a relation between accuracy and type. However, the utility of statistics is lessened with smaller sample sizes. This is especially true when the sample is further divided into groups as with this research.

Some trends were noted when sophisticated statistical analyses were disregarded and a cursory analysis was performed. Three of the type groups - ST, SF, and NT were most accurate with the bar graph alone, while the NF group scored next-to-worse with the same mode. Also, the ST group performed relatively well with pie charts (second-most accurate mode for STs) while the other three type groups performed poorly with them (NFs were least accurate with pie charts versus other modes). This trend information has design implications for MIS applications.

If the audience for the information is ST or primarily ST, the MIS should be designed to provide data as a bar graph or pie graph with no

tabular data. However, the same data given to an NF audience should be put in line or bar graph form with tabular data available.

Question 4. The hypothesis that preference will not vary when using different modes of presentation of information is not accepted. The analyses of the preference rankings revealed that line graph with tabular and bar graph with tabular were most preferred, while the pie chart and bar graph were the least preferred.

The results are biased by the large number of STs in the sample, the results mirror the ST preferences. But even if the audience type is unknown, the MIS designer should determine if the audience has preferences for particular data presentation modes. It is likely that preferences for some modes over others exist.

Question 5. The hypothesis that psychological type has no relation to the preferred mode of presentation of data is accepted. There was no indication from the statistical analysis that the variation of preference was related to psychological type.

Even after cursory trend analysis, differences between the type group preferences were not evident from the data. This finding means that the modes of presentation shown to be preferred in the conclusions of question four are made regardless of the type structure of the audience. Further analysis is necessary prior to making recommendations based on this finding.

Question 6. The hypothesis that accuracy and preference for presentation mode are not related is accepted. The statistical data analysis showed no significant relationship between the preference rank given modes of presentation of data and psychological type.

Cursory trend analysis shows that managers don't always like what is most accurate for them, or the opposite - managers may like the mode, but do poorly with it. It appears the former is more the truth. The non-statistical analysis reveals that most subjects did not prefer the pie chart, yet many were very accurate with it. This shows that if the users of a MIS strongly communicate a preference for a particular presentation mode, this may not indicate they will perform better when they use it.

Question 7. The hypothesis that efficiency is the same for all types of presentation of information is not accepted. Efficiency, as measured by time taken to complete problems, varied depending on the way information was presented. Subjects took the least time to answer questions when presented data as line graphs and bar graphs. The least efficient (most time used) were tabular and pie graph with tabular. The data revealed that whenever tabular information was added to the problem, efficiency decreased. However, all graphs and all combinations of tabular and graphs were more efficient than tabular alone.

The MIS designer should realize that when speed of decision-making is desired, certain presentation modes should be used. In general, pure data in the form of tabular columns requires more time. While this may present all the data, the speed which an MIS user can solve problems with the data is slower than the other modes. If the data lends itself to graphical representation then it should be graphed. Users of MISs often need to make quick management decisions, so the MIS should easily and quickly convert data to graphical form for best -- faster -- use.

Question 8. The hypothesis that psychological type and efficiency are not related is accepted. The analysis showed no relation of type to efficiency.

The data shows no statistical relation, but trends are evident from further non-statistical analysis. The data showed NFs to be more inefficient with line graphs than any other type. NFs were least accurate when they used line graphs, but the other types ranked first or second in accuracy when they use line graphs. Assuming a relationship does exist as the trends suggest, the MIS designer should know the personality type of the eventual user. If fast decisions are to be made, the STs, SFs, and NTs should be allowed to use line graphs, while the NFs would do better to use bar graphs.

Question 9. The hypothesis that efficiency and accuracy are not related is not accepted. Efficiency and accuracy were shown to have a strong relationship.

This relationship shows that a problem solver may use more time on a problem, but the time problably pays off with a more accurate answer. The implications for MIS design are that if the MIS user needs more time to solve a problem, the system should be flexible enough to allow the extra time in order to maximize the accuracy. More research needs to be accomplished in order to show if there is a point of diminishing returns. That is, see if there is a point where the more time the subject uses, the less accurate the answer becomes.

Central Research Question. The hypothesis that type is not related to mode of presentation is accepted. On the basis of the statistical analysis of questions 3, 5 and 8 the hypothesis of no relation is accepted. Even though the statistical analyses show no significant relation, the trend

analyses show some very strong implications that relationships could exist, if the sample size were larger.

These trends evident in the data do not support the hypothesis that there is no relationship, but in fact there is a real connection between type and presentation mode. If these trends are assumed valid, the MIS designer should become aware of the correlations between type and success at problem solving using different modes of presentation. Take for example the type most evident in the population - ST. If MIS designers need a template for which mode of presentation to use, the ST would be a good choice.

First, the designer would look at what purpose the data will serve. If the problem demands accuracy, data should be presented in bar graph or pie graph form. However, if the data has to be preferred to be useful, pie charts should be avoided in favor of line graphs or bar graphs, each with tabular data. Still another possible use may be efficiency - if this is the main design characteristic, data should be in line graph form, with or without tabular data as a supplement.

Recommendations and Applications

These findings have potential application in every MIS design initiative. The designer is faced with the choice of which way to have the system present the data to the user. Should the user be allowed to pick which mode to have? The resuts here indicate no. Preference for and success with presentation modes are not significantly related. Trends indicate that preference and success may even run counter to one-another.

The designer should choose which presentation mode will be used in the majority of situations. How can this choice be made? It would not be effective for the designers to pick which mode they most prefer. If

preference and success were positively related, the type of the designer is likely different than the type of the intended audience.

How, then, should designers choose which mode to use? By looking at the eventual use of the data and the type of the user. The results show trends which will benefit in finding the proper data-mode/user-type fit.

There are many factors which can confound the results of this type of study. Recommendations made for future research are concerning control of variance due to demographics, problem selection, and sample size.

There are going to be some background noises which may affect the reliability of the results in an experiment regarding psychological type. Some of the potential noise may be contained in the use of demographics to represent independent variables. Demographics in this case refer to a subject's age, sex, experience and other factors. These factors, while not the main focus of this research, may have an effect on the results of any similar research, therefore their influence on the independent variables should be measured. Another influential demographic factor may be background experiences. This same study should be performed on non-government and non-academically affiliated groups in order to further validate the results for the general population.

The problem type is of central importance to the results of this study. While this study did not measure the influence of problem type, this is a factor which needs more study. The problem could be varied from a profit-oriented scenario to a personnel-oriented scenario in order to possibly differentiate between the psychological type preferences. Thinking types may prefer the data and profit orientations, while the feeling types may be shown to prefer more personal issues.

The study conducted here should be replicated in order to further substantiate the results and to statistically analyze noticeable trends. The small sample size of the research makes statistical analysis and significance of results difficult to ascertain and evaluate. A follow-on study which uses an even distribution of type should be considered.

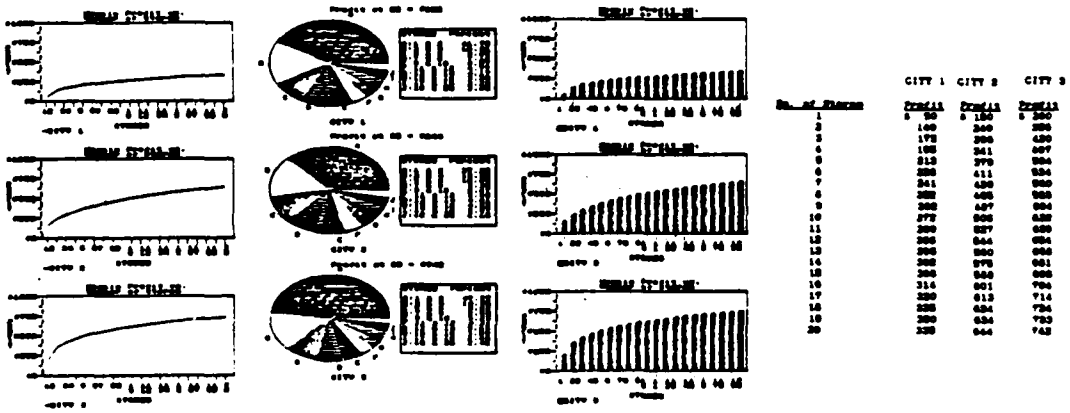
Appendix: Information Presentation Mode Survey

For each of the following 7 problems (A thru G), assume you are the regional director of a national pizza chain - "CHECKERS" - and you have a decision to make. The national headquarters of CHECKERS has determined that you can open twenty new stores this year in your region. You have conducted an extensive market survey, which is highly reliable, and you have narrowed it down to three candidate cities in each problem. Everything else between the three cities being about equal, you are going to use profit amounts to decide the number of stores in each city. The market survey gave you weekly profit figures for the number of new stores opened in each city.

Do your best to maximize your profit for each problem when you choose how to spread the 20 new CHECKER stores for that problem among the 3 cities. You can allocate from zero to twenty stores to any one city.

Basic constraints and assumptions are the same for all five problems, however each of the five problems have different data sets, so the number of new stores that are given to CITY 1 in PROBLEM A will probably differ from the number given to CITY 1 in PROBLEM B. The TIME START and TIME STOP notations may be noted as times of day to show elapsed time.

Some of the problems have the information graphed, some in lists of numbers and some have both - below is an example of all the types of information with three possible ways of spreading the 20 stores among the 3 cities:



NOTES FOR PIE CHARTS:

- The total *Profit at 20* stores may differ for each city
- The percent shown represents the additional profit when the two stores indicated are added.

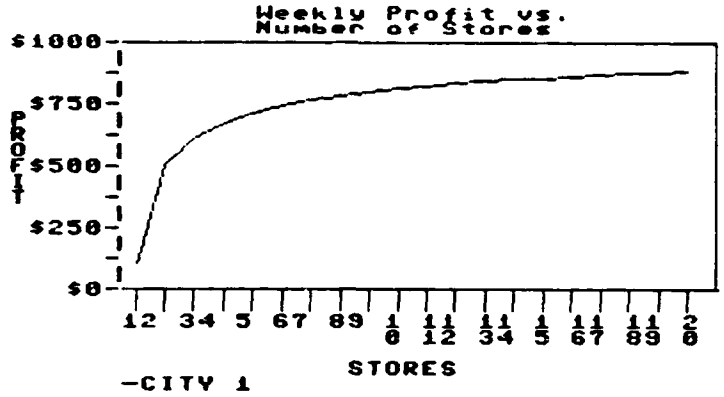
THREE POSSIBLE MIXES:

	No. of Stores	Profit		No. of Stores	Profit		No. of Stores	Profit
CITY 1:	7	$ 241	CITY 1:	4	$ 195	CITY 1:	0	$ 0
CITY 2:	5	379	CITY 2:	4	341	CITY 2:	10	508
CITY 3:	8	583	CITY 3:	12	654	CITY 3:	10	622
Totals	20	$1203	Totals	20	$1190	Totals	20	$1130

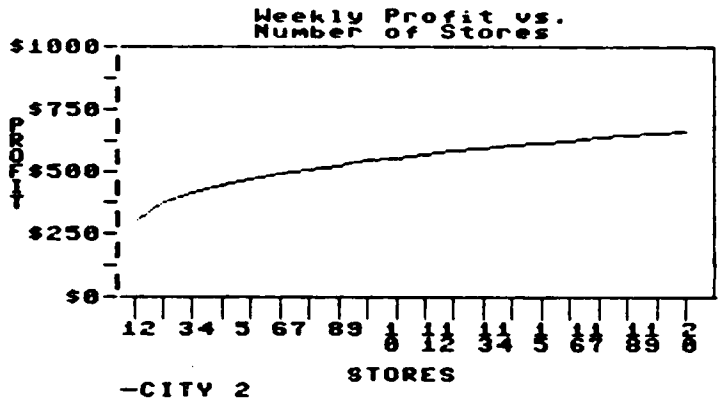
*** REMEMBER:

-- ATTEMPT TO MAXIMIZE PROFIT IN EACH PROBLEM
-- USE ALL 20 STORES IN EACH PROBLEM
-- WRITE DOWN THE TIME START AND TIME STOP FOR EACH PROBLEM

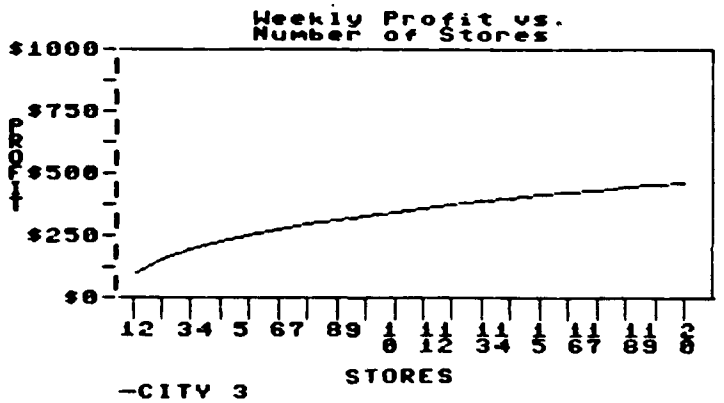
PROBLEM A TIME START _____



—CITY 1



—CITY 2



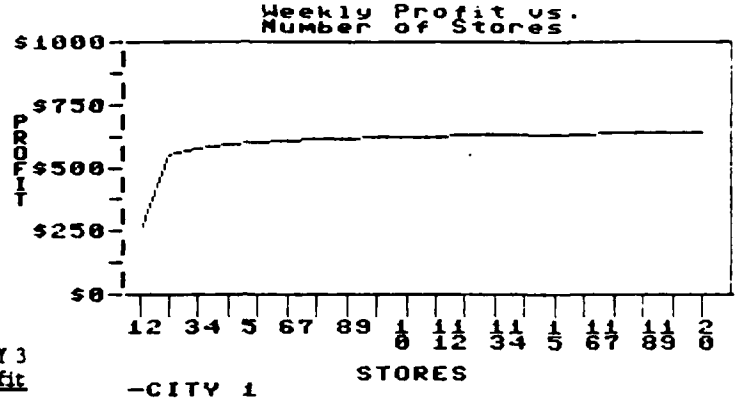
—CITY 3

No. of Stores CITY 1 _____ No. of Stores for CITY 2 _____ No. of Stores for CITY 3 _____ TIME STOP _____

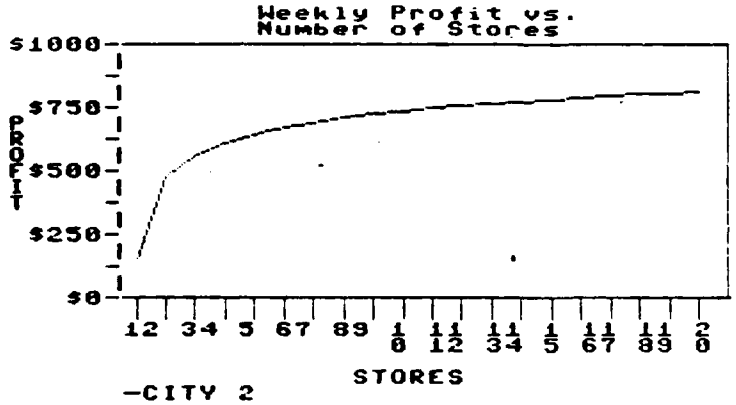
PROBLEM B

TIME START _____

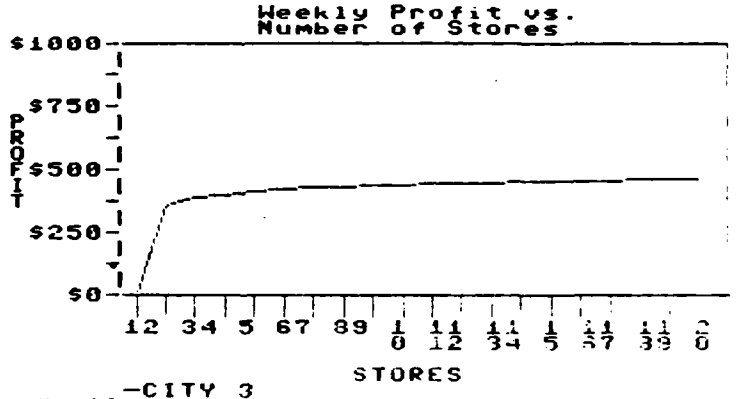
No. of Stores	CITY 1 Profit	CITY 2 Profit	CITY 3 Profit
1	250	150	10
2	560	482	365
3	583	562	391
4	596	611	406
5	605	646	417
6	612	673	425
7	618	695	431
8	622	712	436
9	626	728	440
10	629	741	444
11	631	753	447
12	634	763	450
13	636	772	452
14	637	780	455
15	639	788	456
16	640	794	458
17	641	801	460
18	643	806	461
19	643	812	462
20	644	816	463



—CITY 1



—CITY 2



—CITY 3

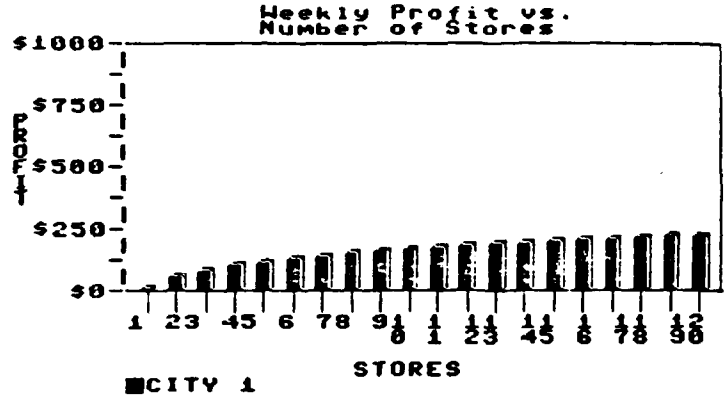
No. of Stores for CITY 1 _____

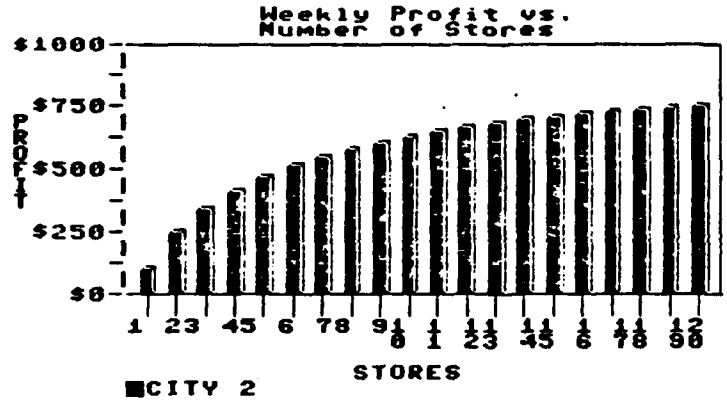
No. of Stores for CITY 2 _____

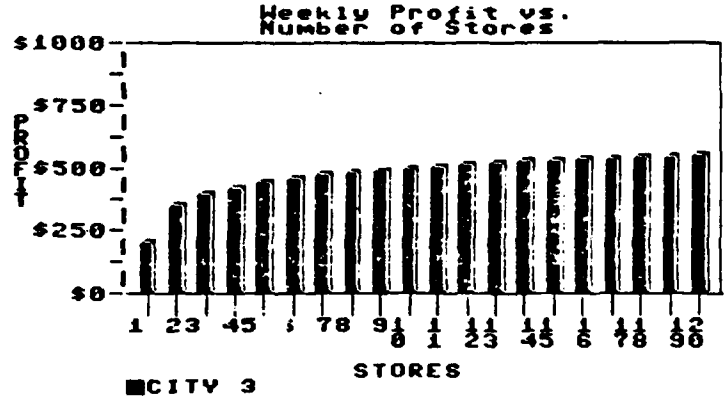
No. of Stores for CITY 3 _____

TIME STOP _____

PROBLEM C TIME START _____

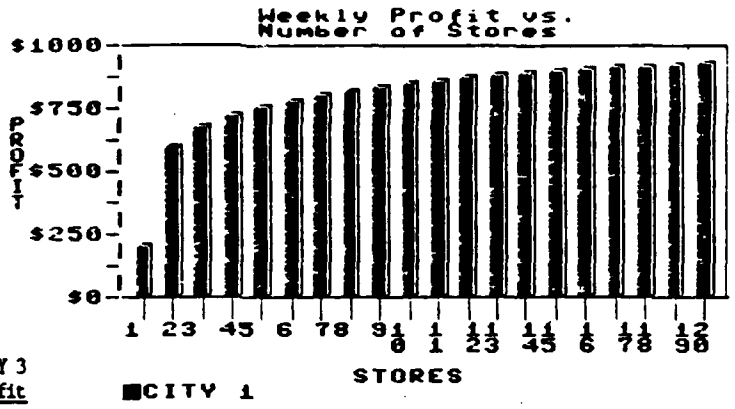




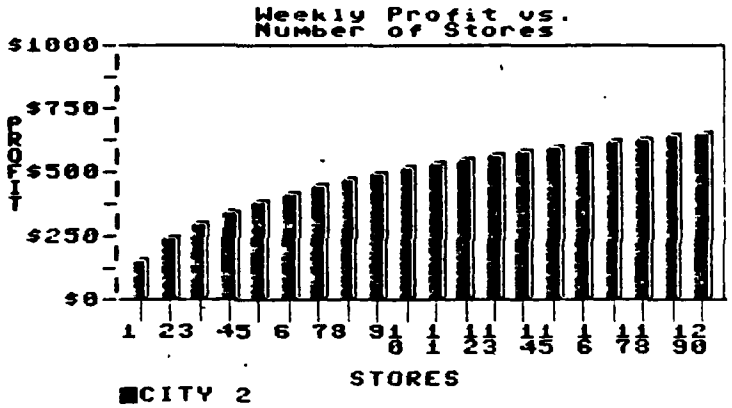


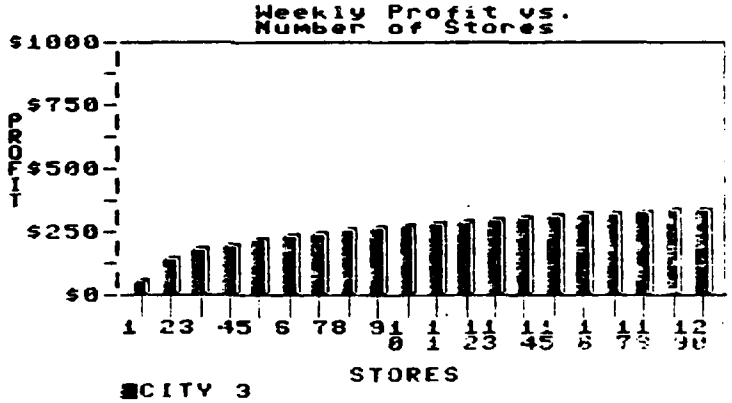
No. of Stores for CITY 1 _____ No. of Stores for CITY 2 _____ No. of Stores for CITY 3 _____ TIME STOP _____

PROBLEM D TIME START _____



No. of Stores	CITY 1 Profit	CITY 2 Profit	CITY 3 Profit
1	200	150	50
2	599	240	140
3	675	296	172
4	721	341	195
5	754	379	213
6	780	411	228
7	801	439	241
8	819	465	252
9	834	487	262
10	847	508	272
11	858	527	280
12	868	544	288
13	878	560	295
14	886	575	302
15	894	588	308
16	901	601	314
17	907	613	320
18	913	624	325
19	918	634	330
20	924	644	335

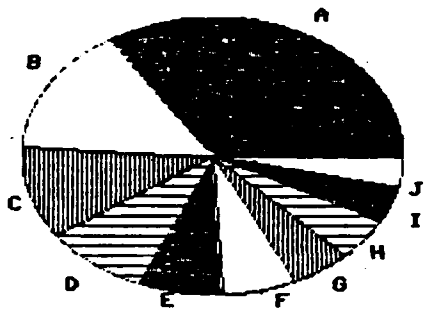




No. of Stores for CITY 1 _____ No. of Stores for CITY 2 _____ No. of Stores for CITY 3 _____ TIME STOP _____

PROBLEM E TIME START ________

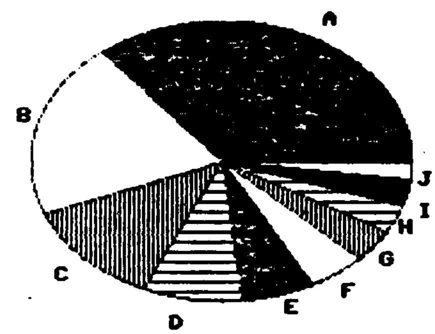
Profit at 20 = $463



STORES	Percent
A: 1 & 2	34.12
B: 3 & 4	14.90
C: 5 & 6	10.79
D: 7 & 8	8.63
E: 9 & 10	7.34
F: 11 & 12	6.26
G: 13 & 14	5.18
H: 15 & 16	4.75
I: 17 & 18	4.31
J: 19 & 20	3.67

CITY 1

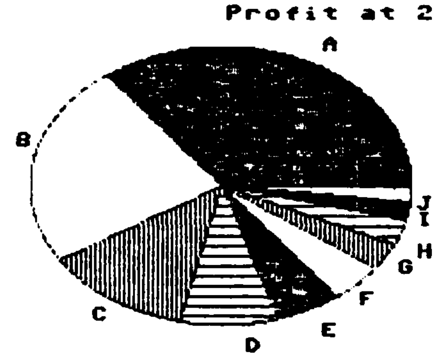
Profit at 20 = $691



STORES	Percent
A: 1 & 2	35.93
B: 3 & 4	20.34
C: 5 & 6	11.97
D: 7 & 8	8.36
E: 9 & 10	6.20
F: 11 & 12	4.90
G: 13 & 14	3.89
H: 15 & 16	3.17
I: 17 & 18	3.03
J: 19 & 20	2.16

CITY 2

Profit at 20 = $791



STORES	Percent
A: 1 & 2	35.39
B: 3 & 4	23.51
C: 5 & 6	12.64
D: 7 & 8	8.09
E: 9 & 10	5.81
F: 11 & 12	4.29
G: 13 & 14	3.41
H: 15 & 16	2.78
I: 17 & 18	2.14
J: 19 & 20	1.89

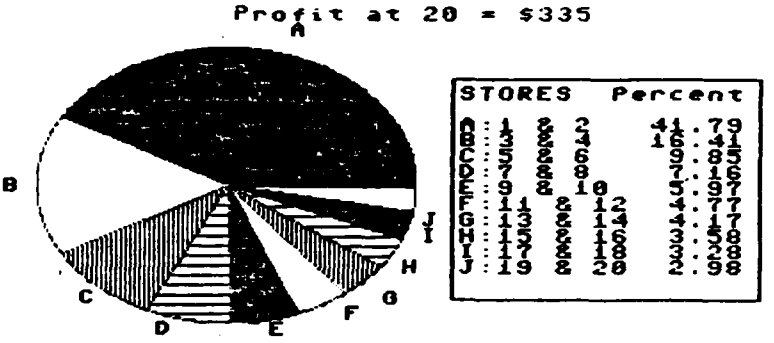
CITY 3

No. of Stores for CITY 1	No. of Stores for CITY 2	No. of Stores for CITY 3
________	________	________

TIME STOP ________

PROBLEM F TIME START _____

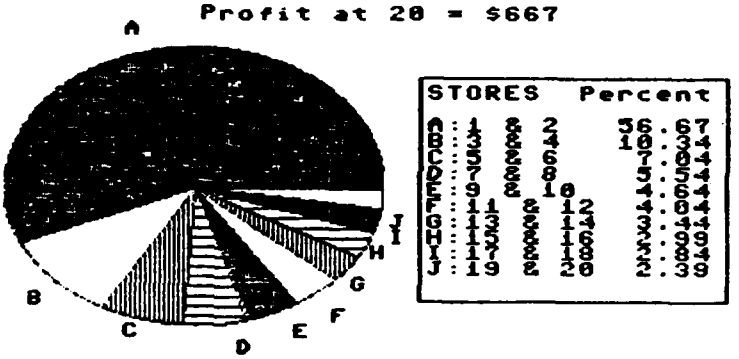
Profit at 20 = $335



CITY 1

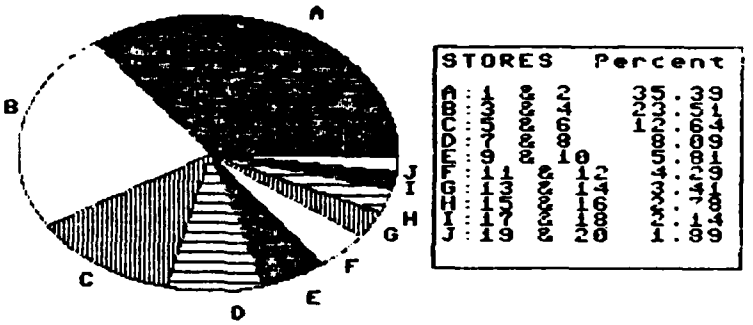
No. of Stores	CITY 1 Profit	CITY 2 Profit	CITY 3 Profit
1	50	300	50
2	140	378	280
3	172	417	391
4	195	447	466
5	213	472	522
6	228	494	566
7	241	514	601
8	252	531	630
9	262	547	655
10	272	562	676
11	280	576	694
12	288	589	710
13	295	600	725
14	302	612	737
15	308	622	748
16	314	632	759
17	320	642	768
18	325	651	776
19	330	659	784
20	335	667	791

Profit at 20 = $667



CITY 2

Profit at 20 = $791



CITY 3

No. of Stores for CITY 1 _____

No. of Stores for CITY 2 _____

No. of Stores for CITY 3 _____

TIME STOP _____

PROBLEM G TIME START _____

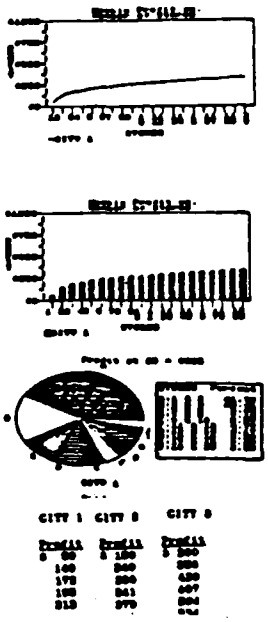
No. of Stores	CITY 1 Profit	CITY 2 Profit	CITY 3 Profit
1	$ 50	$ 250	$ 100
2	140	313	573
3	172	346	606
4	195	371	626
5	213	392	639
6	228	410	649
7	241	426	657
8	252	440	663
9	262	452	669
10	272	463	674
11	280	474	678
12	288	483	681
13	295	492	685
14	302	500	688
15	308	508	690
16	314	515	692
17	320	521	694
18	325	528	696
19	300	533	698
20	335	539	700

No. of Stores for CITY 1	No. of Stores for CITY 2	No. of Stores for CITY 3
_____	_____	_____

TIME STOP _____

Now that you have completed all seven problems, please rank order your preference for the ways information was presented to you in this survey. Use the numbers from 1 to 7 to indicate how you preferred the information to be presented, with 1 being your most preferred - on down to 7, your least preferred method.

RANK	METHOD
____	Line Graph Alone
____	Line Graph with Columns of Figures
____	Bar Chart Alone
____	Bar Chart with Columns of Figures
____	Pie Chart Alone
____	Pie Chart with Columns of Figures
____	Columns of Figures Alone



Please answer one of the two questions below if unable to rank preferences:

____ Prefer all methods of presentation equally well

____ Don't prefer any of the methods of presentation

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VITA

First Lieutenant Eric A. Thomas was born on 19 May 1960 in Salem, Oregon. He graduated from high school in Dallas, Oregon in 1977 and attended Oregon State University in Corvallis, Oregon. He received his Bachelor of Science in Business Administration in 1981. Upon graduation, he moved to Honolulu, Hawaii and was the sole owner and proprietor of a tax and accounting services business. In 1984 he was accepted for admission into the United States Air Force Officer Training School at Lackland AFB, Texas. He attended and received his commission in September of that same year. Upon receiving his commission, Lieutenant Thomas attended Administration Officer Course at Keesler AFB, Mississippi. He qualified as an Honor Graduate from the Administration Officer Course and then was assigned as the Adjutant to the Commandant, United States Air Force Fighter Weapons School, Nellis AFB, Nevada. Lieutenant Thomas served as Adjutant until May 1986 when he entered the Air force Institute of Technology School of Systems and Logistics.

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Associate Professor

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Block 19. Abstract

The objective of this research was to identify a relationship between psychological type and mode of presentation of information. The type theory developed by Carl Jung and operationalized by the Myers-Briggs Type Indicator (MBTI) was used to identify psychological type. The information presentation data were collected through an Inforamtion Presentation Mode Survey.

The population studied was graduate students at the Air Force Institute of Technology. The results of the MBTI were combined to show cognitive style. The Information Presentation Mode Survey gathered data regarding accuracy, efficiency and preference rankings for seven different modes of presentation of data.

The statistical analyses showed no relationship between personality type and presentation mode, however sample size made analysis difficult. Trends evident in the data suggested that personality type and presentation modes were related.

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